

HFIR Fundamental Neutron Physics Beamline

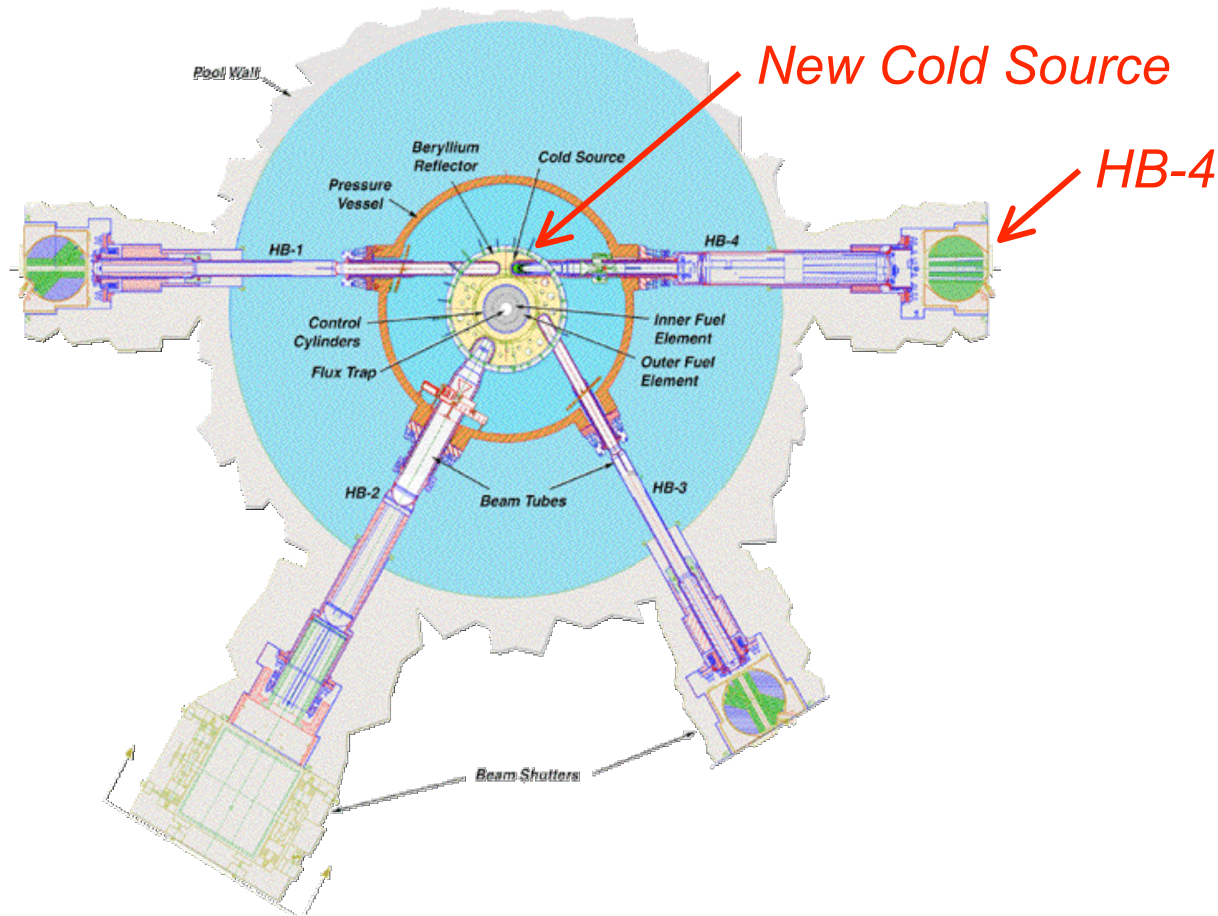
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University of Tennessee



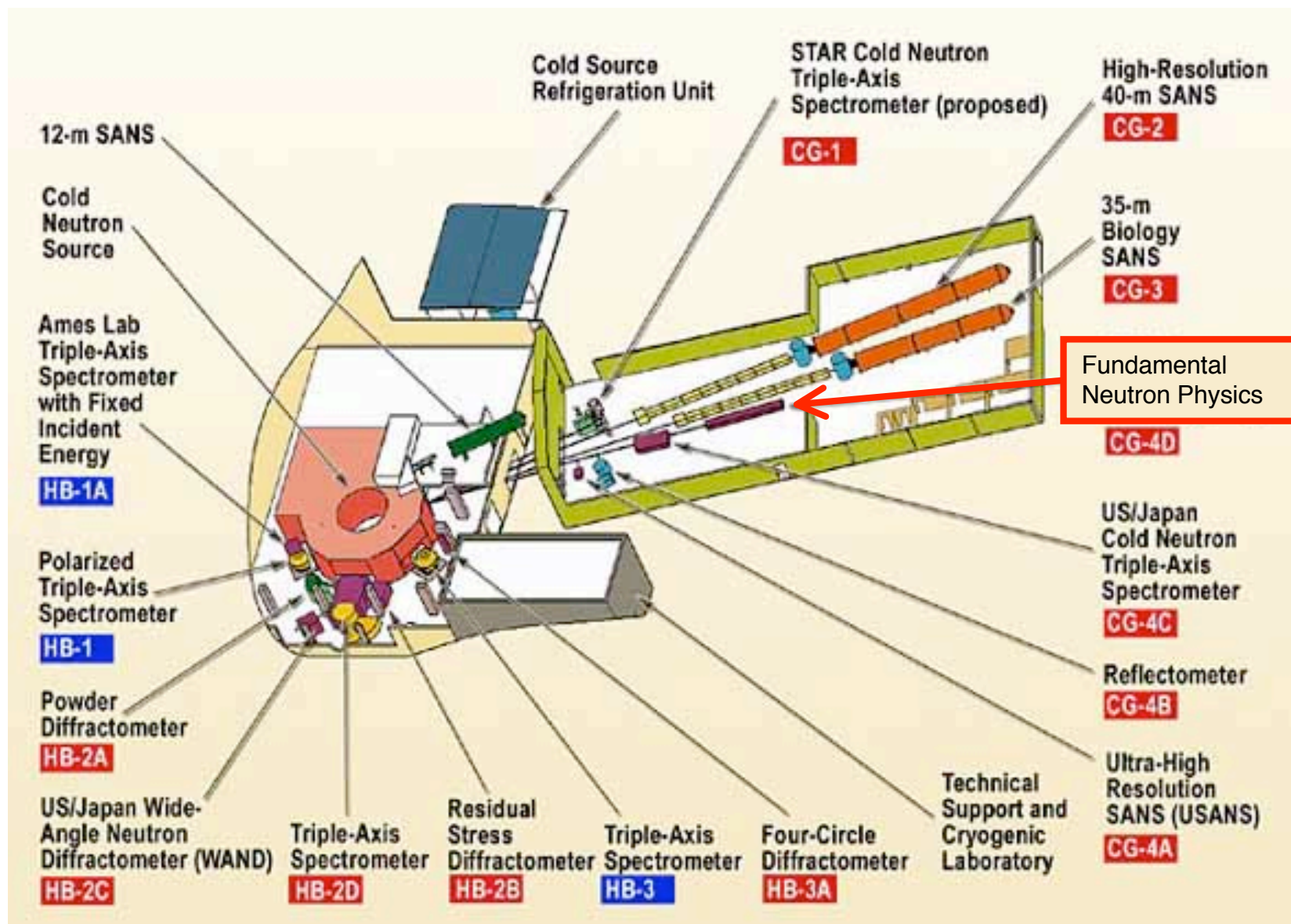
- *The High Flux Isotope Reactor and the HFIR Upgrade*
- *The Fundamental Neutron Physics Beamline at HFIR*
 - *Neutron guide design*
 - *Expected performance*
 - *Preliminary shielding calculation*
- *Schedule + Action items*

HFIR is the World's Highest Power Research Reactor

*An upgrade that is in progress will provide
a cold neutron source with a brightness equal to the ILL*



Cold Neutron Guide Hall at HFIR



The New HFIR Guide Hall



HFIR Upgrade Project

- *Upgrade is fully funded from BES*
- *Upgrade includes new experimental hall, cold source, neutron guides, utilities, and scattering instruments (2xSANS, 2x3Axis, & Reflectometer)*
- *Low power operation with cold source and guides anticipated in Dec, 2005*
- *Full power operation in April 2006*

The HFIR Upgrade is One of Three National Priorities for Neutron Science identified by the White House Office of Science and Technology Policy

Implementation Priority 1:

The Department of Energy, the National Science Foundation, and other interested agencies, should immediately establish a framework for an interagency partnership to provide funding resources to develop and operate a robust suite of instruments, approximately 75% of full instrumentation, to address a broad spectrum of neutron scattering measurements at the SNS. To be timely, the framework for instrument development should be affected within the next six months.

Implementation Priority 2:

The IWG recommends that NIST and the Department of Commerce along with their partners, including the National Science Foundation, continue to fully support: 1) the source operations of the NCNR; 2) the improvements in source and instrument capability; and 3) the increased levels of support for both the NIST research program the general science community.

Implementation Priority 3:

The IWG recommends that the Department of Energy should fully support the cold source and instrument upgrade project at the HFIR and ensure that the instruments are operated to support a robust general user program .

Source “The Status and Needs of Major Neutron Scattering Facilities and Instruments,” OSTP, 2002

Comparison of Neutron Facilities in the US

Facility	Status	Op days per year Note 1	Guide Area (cm ²)	(Guide) ² m Note 2	Cold source Brightness at ~4Å (10 ¹⁰ n/cm ² /s/sr/Å)	Relative Brightness *Area*Year Note 3	Relative Yearly Fluence Note 3
Pulsed Sources							
Lujan (FP12)	Op	104 85%	90	9	2.5	1	1
SNS (FP13)	<i>Prop</i>	208	120	12	71	76	101
Continuous Sources							
NIST (NG6)	Op	266 100%	36 Note 4	1.4	150	61	10
HFIR (HB4)	<i>Prop</i>	261 93%	22 Note 5	4	450	110	50 Note 5
PSI	Op	245	120	9	60	75	75
ILL (PF1b)	Op	200	120	4	450	460	205

Source: Tribble et. al., 2003

Npdgamma Collaboration Meeting, LANL September 2004



Comparison of Neutron Facilities in the US

Facility	Status	Op days per year <small>Note 1</small>	Guide Area (cm ²)	$\left(\frac{\text{Guide}}{\text{m}}\right)^2$ <small>Note 2</small>	Cold source Brightness at $\sim 4\text{\AA}$ (10^{10} n/cm ² /s/sr/ \AA)	Relative Brightness *Area*Year <small>Note 3</small>	Relative Yearly Fluence <small>Note 3</small>
Pulsed Sources							
Lujan (FP12)	Op	104 85%	90	9	2.5	1	1
SNS (FP13)	<i>Prop</i>	208	120	12	71	76	101
Continuous Sources							
NIST (NG6)	Op	266 100%	36 <small>Note 4</small>	1.4	150	61	10
HFIR (HB4)	<i>Prop</i>	261 93%	22 <small>Note 5</small>	4	450	110	50 25 <small>Note 5</small>
PSI	Op	245	120	9	60	75	75
ILL (PF1b)	Op	200	120	4	450		

Guide Losses in $\sim 35\text{m}$ of curved guides results in a reduction of $\sim x2$.

Source: Tribble et. al., 2003

Npdgamma Collaboration Meeting, LANL September 2004



*What is needed for npdgamma at HFIR?**

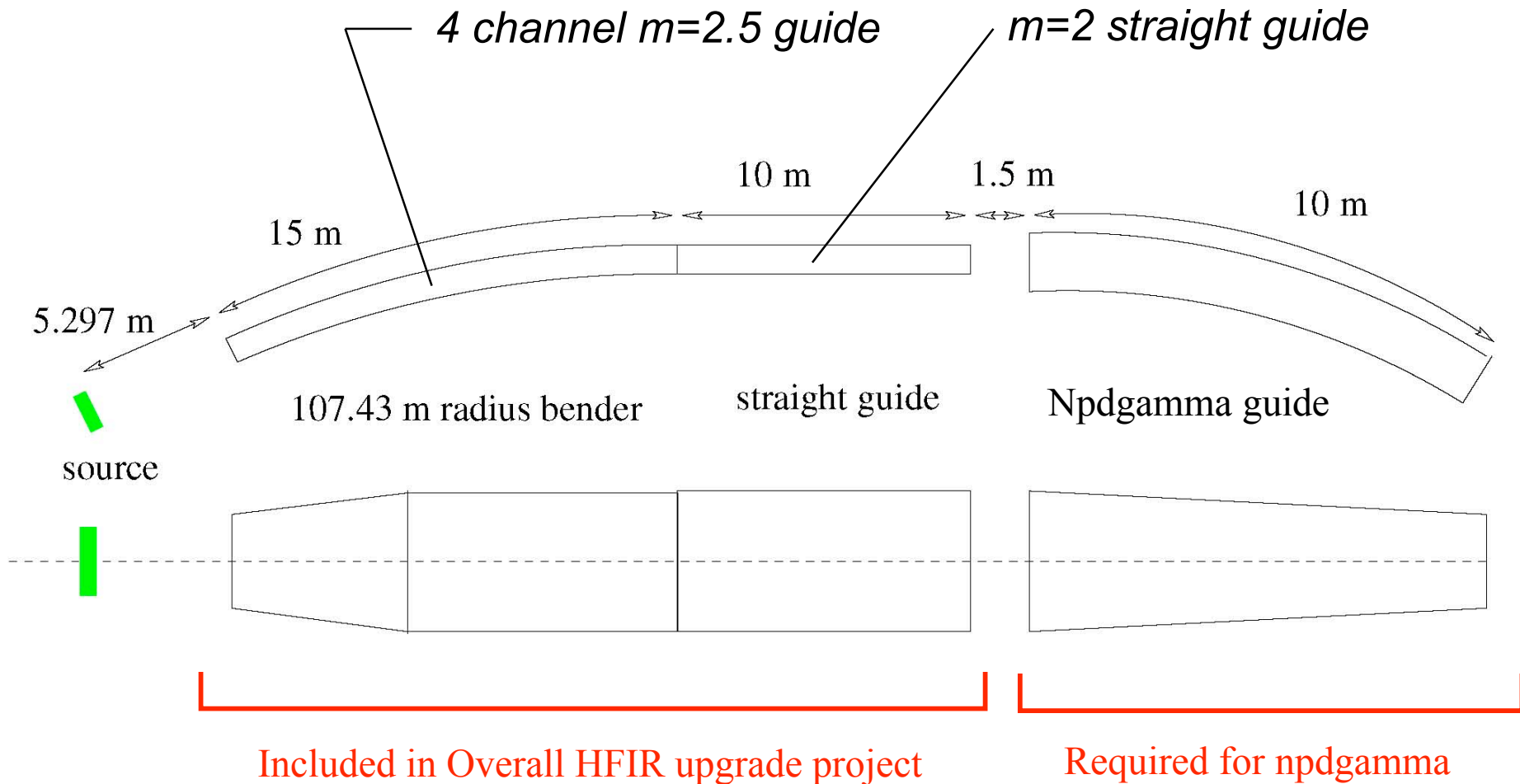
- *~10m of neutron guide*
- *Neutron guide shielding*
- *Experiment shielding*
- *Liquid H₂ authorization*
- *Shutter and miscellaneous components*

**Over and above the HFIR upgrade project*

HFIR neutron guide design consideration

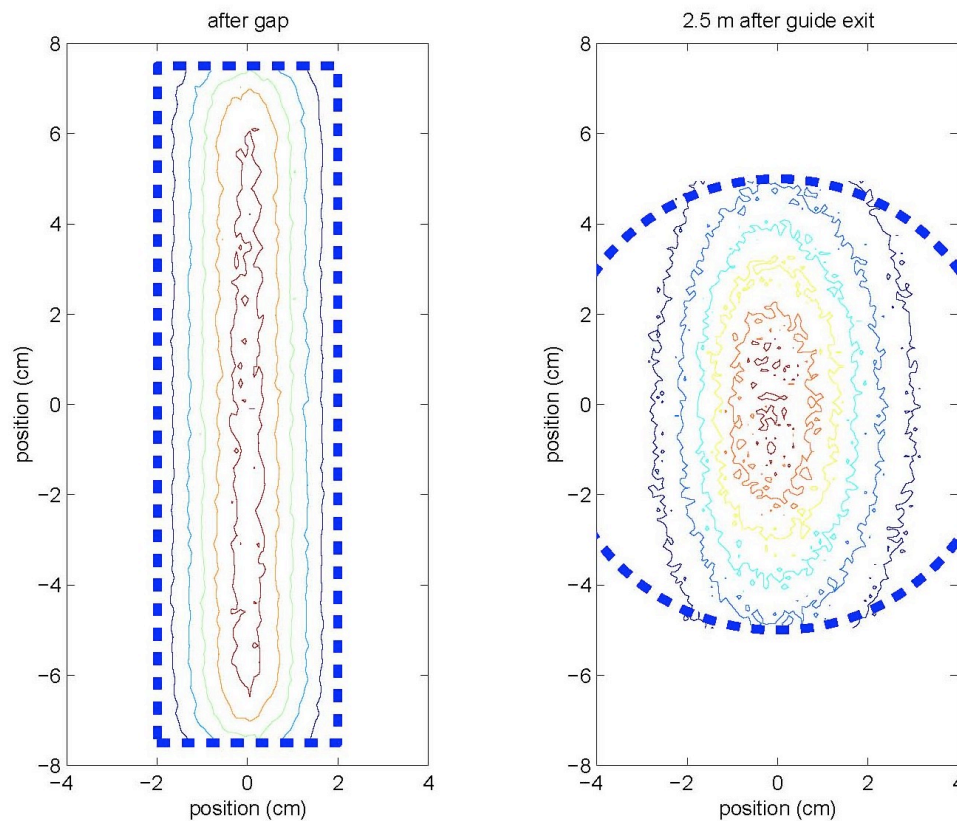
- *Space between our beamline and the adjacent beamline*
(Personnel access to the SANS neutron collimator controller + space for radiation shielding)
→ *Need an extra bend*
- *Matching between the HFIR guide and the npdg experiment*
(Exit of CG4 guide: 15cmx1.9cm)
→ *Vertically tapered (“parabolic”) guide*

HFIR guide proposed design

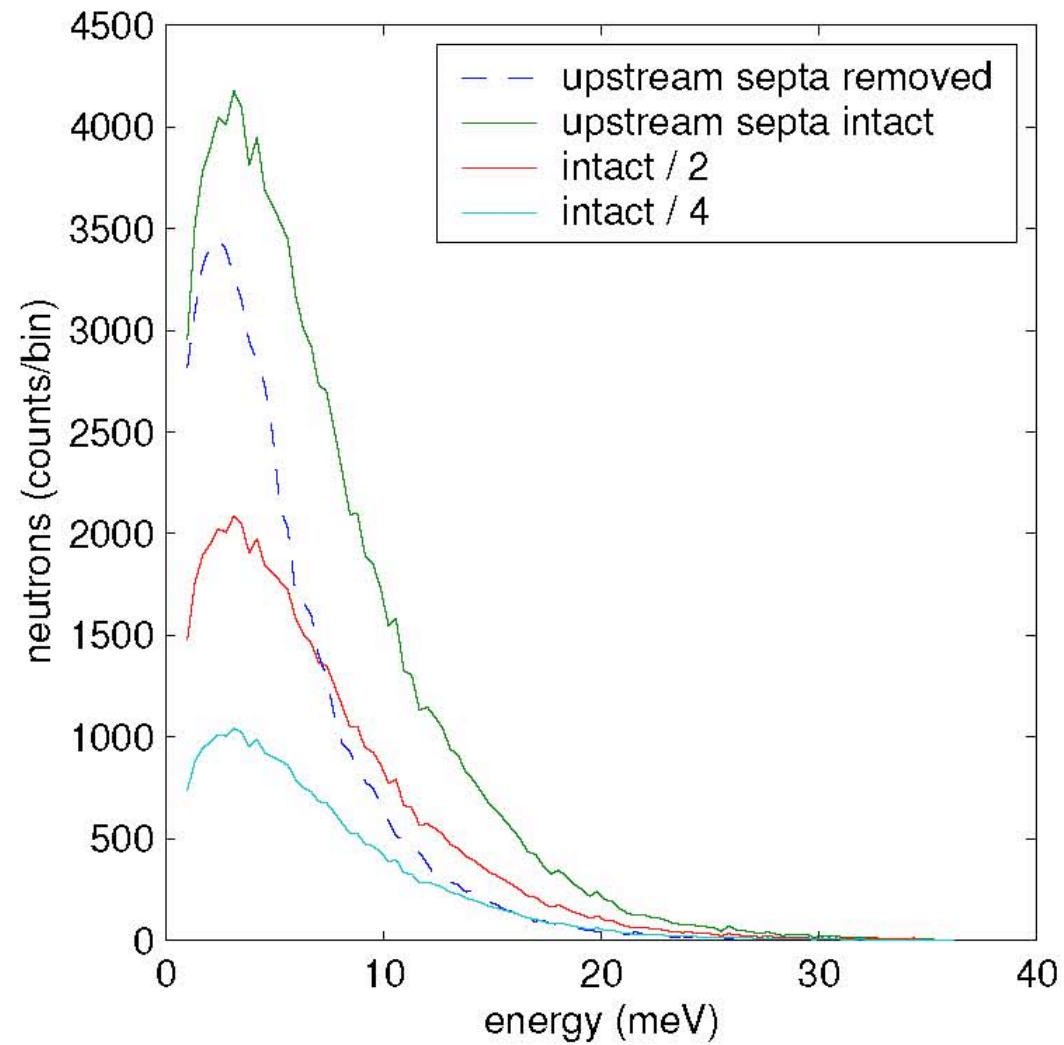


Matching the HFIR Guide to npd γ

Because the HB-4 guide is $m=2$, it is possible to vertically “focus” the neutrons with an $m=3.5$ tapered guide



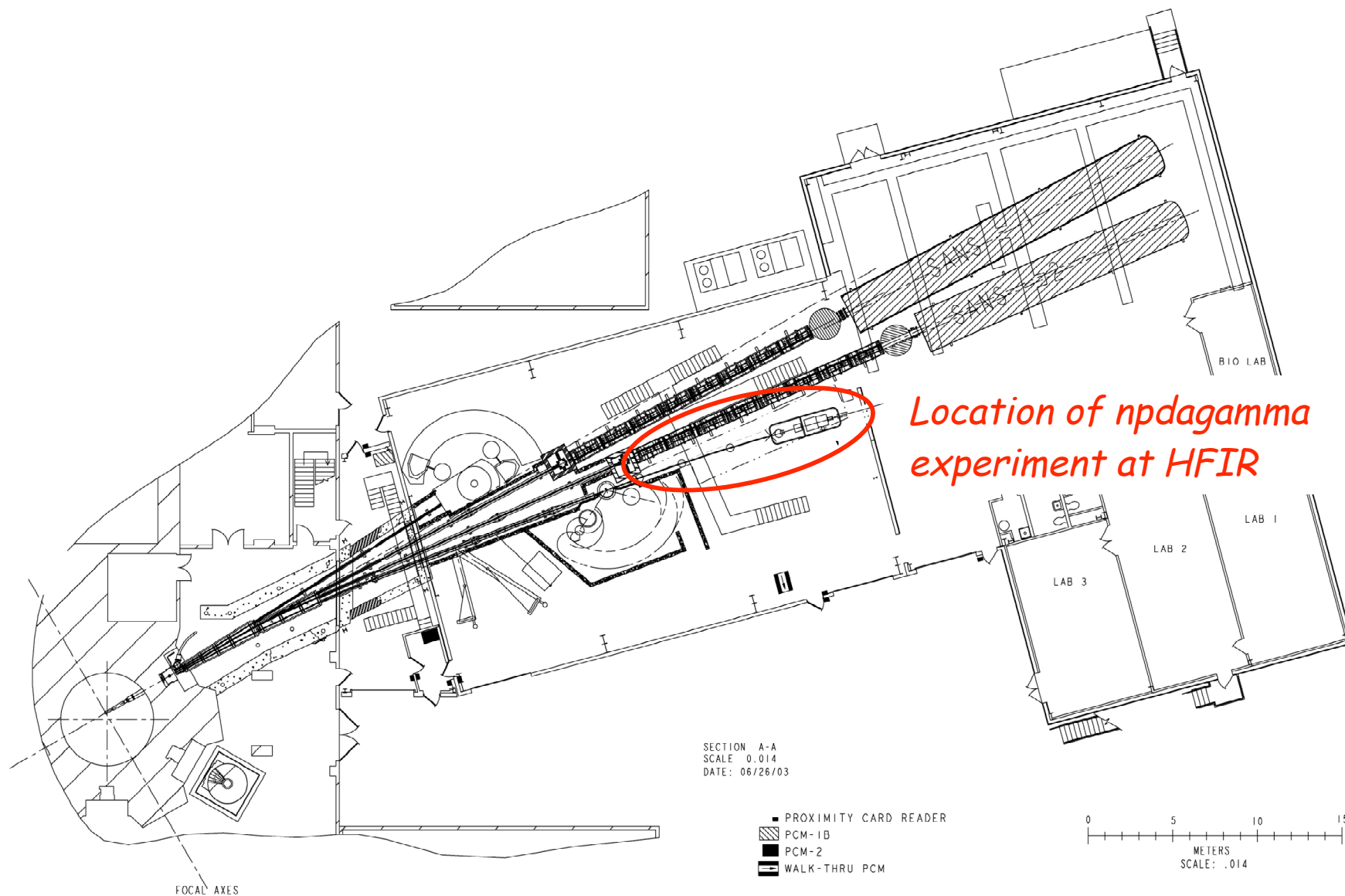
Expected neutron spectrum



Expected neutron flux

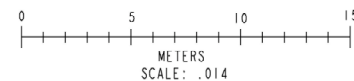
<i>Guide design</i>	<i>Upstream septa</i>	<i>Bender length (m)</i>	<i>Radius of Curvature (m)</i>	<i>Number of channels</i>	<i>Neutron density (10^3 n/cm³)</i>	<i>Neutron fluence (10^{10} n/s)</i>
<i>Long bender</i>	<i>yes</i>	<i>10</i>	<i>120</i>	<i>4</i>	<i>14.7 ± 0.4</i>	<i>3.23 ± 0.03</i>
<i>Short bender</i>	<i>yes</i>	<i>2</i>	<i>36.80</i>	<i>10</i>	<i>12.4 ± 0.4</i>	<i>3.21 ± 0.03</i>
<i>Very short bender</i>	<i>yes</i>	<i>0.5</i>	<i>9.80</i>	<i>24</i>	<i>9.1 ± 0.3</i>	<i>2.40 ± 0.02</i>
<i>Long bender</i>	<i>no</i>	<i>10</i>	<i>120</i>	<i>4</i>	<i>8.1 ± 0.3</i>	<i>1.86 ± 0.02</i>
<i>Short bender</i>	<i>no</i>	<i>2</i>	<i>36.80</i>	<i>10</i>	<i>7.7 ± 0.3</i>	<i>1.90 ± 0.02</i>
<i>Very short bender</i>	<i>no</i>	<i>0.5</i>	<i>9.80</i>	<i>24</i>	<i>6.0 ± 0.3</i>	<i>1.43 ± 0.02</i>

Gain in fluence (with respect to FP12) is approximately x10
 Gain in neutrons delivered per year is approximately x25



SECTION A-A
SCALE 0.014
DATE: 06/26/03

- PROXIMITY CARD READER
- ▨ PCM-1B
- PCM-2
- WALK-THRU PCM



CAUTION NUCLEAR EQUIPMENT
ANY PROCESS OR MATERIAL, INCLUDING PROCESSING
OR STORAGE MATERIALS, THAT USE THE FOCUS BEAM
OR EXPOSED MATERIALS CONTAINS AND/OR RELEASES
RADIOACTIVE MATERIALS. RADIOACTIVE MATERIALS
MAY BE PRESENT IN THE BEAM LINE, TARGET, AND
THE SURFACE OF ANY OF THE COMPONENTS AFTER FINAL
CLEANING. DO NOT USE OR DISPOSE OF ANY FORM
OF RADIOACTIVE MATERIALS IN THE BEAM LINE OR
IN ALL PROCESSING AND MANUFACTURING OPERATIONS.

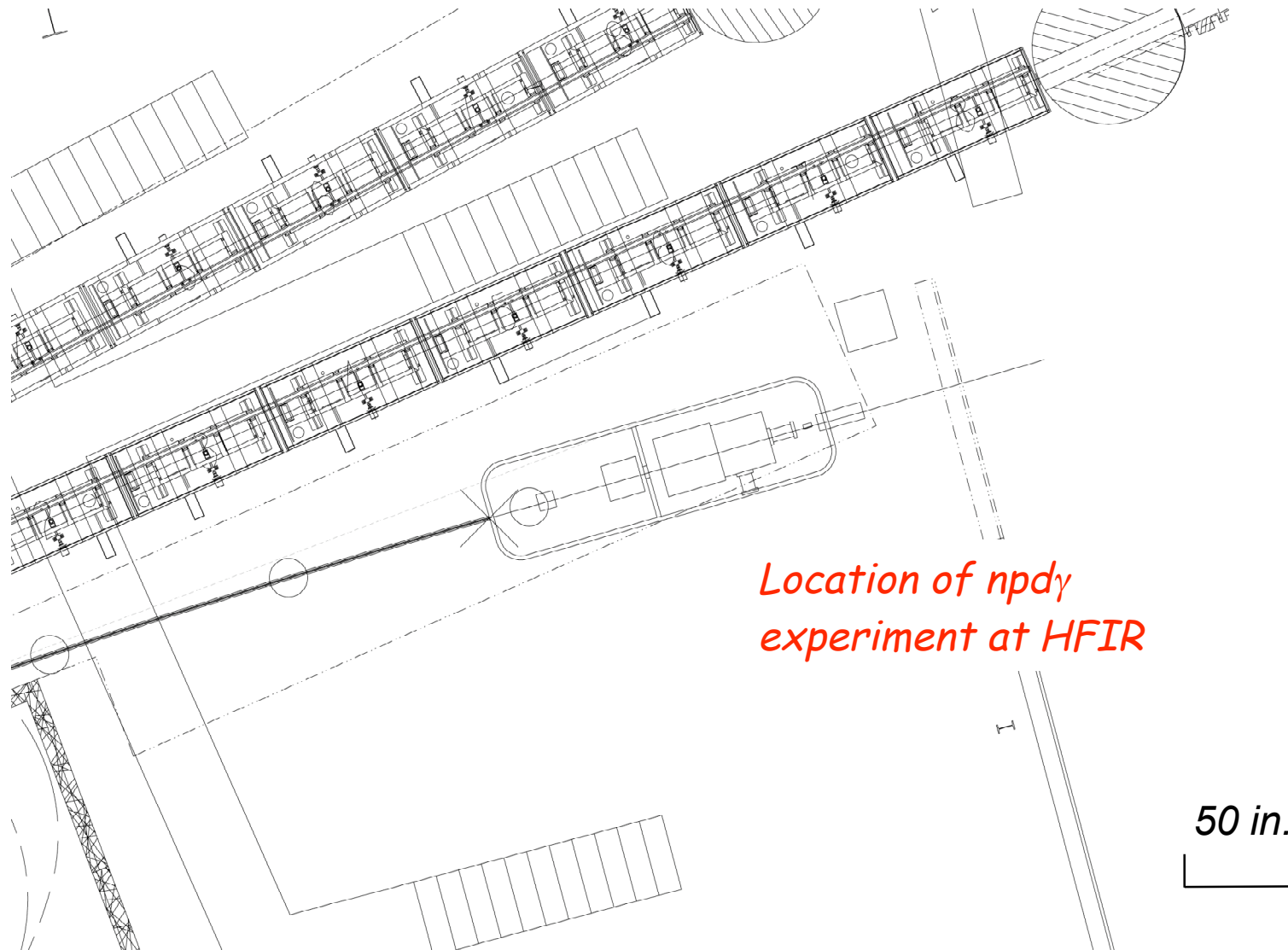
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GENERAL SPECIFICATIONS
UNLESS OTHERWISE SPECIFIED:
① BREAK ALL SHARP EDGES
② FILLETS TO BE MAX
③ MACHINED SURFACE FINISH
SHALL NOT EXCEED:
(LAND) 1/16 IN. - 1/8 IN.

TOLERANCES UNLESS
OTHERWISE SPECIFIED:
FRACTIONS ± .001
DECIMALS ± .001
ANGLES ± .001
SCALE: AS INDICATED

0 BASELINE DESIGN		UT BATTELLE		OAK RIDGE NATIONAL LABORATORY	
NO. 7900		RESEARCH REACTORS DIVISION		FACILITY H.F.I.R.	
REVISIONS		DATE		DATE	
DATE	BY	DATE	BY	DATE	BY
DATE	BY	DATE	BY	DATE	BY
HB-4 BEAM LINE ASSEMBLY		HB-4 BEAM LINE ASSEMBLY		HB-4 BEAM LINE ASSEMBLY	
REV 0 BASELINE LAYOUT		REV 0 BASELINE LAYOUT		REV 0 BASELINE LAYOUT	
X3E017108E002		X3E017108E002		X3E017108E002	

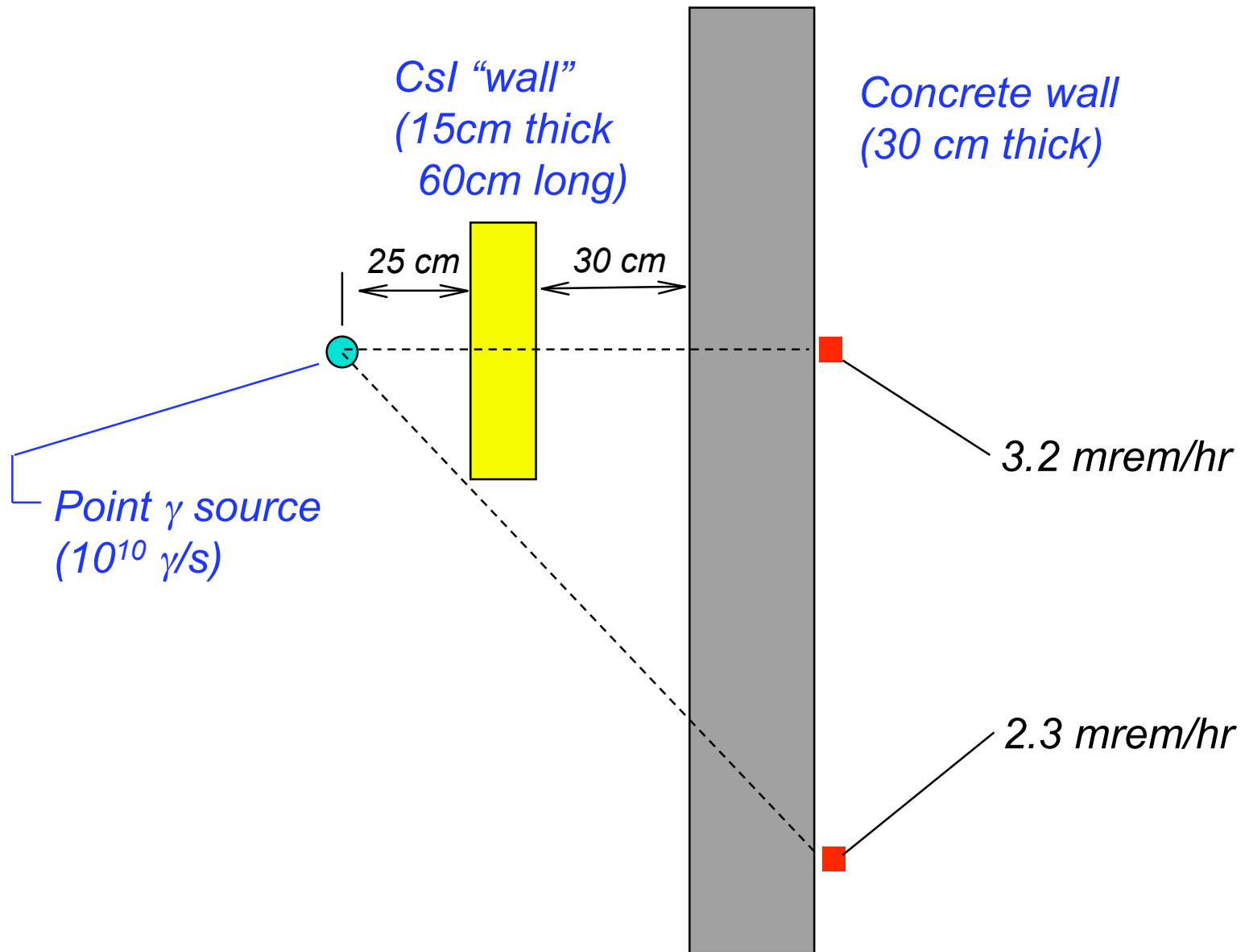
Footprint of npd γ in HFIR guide hall



Radiation shielding issues

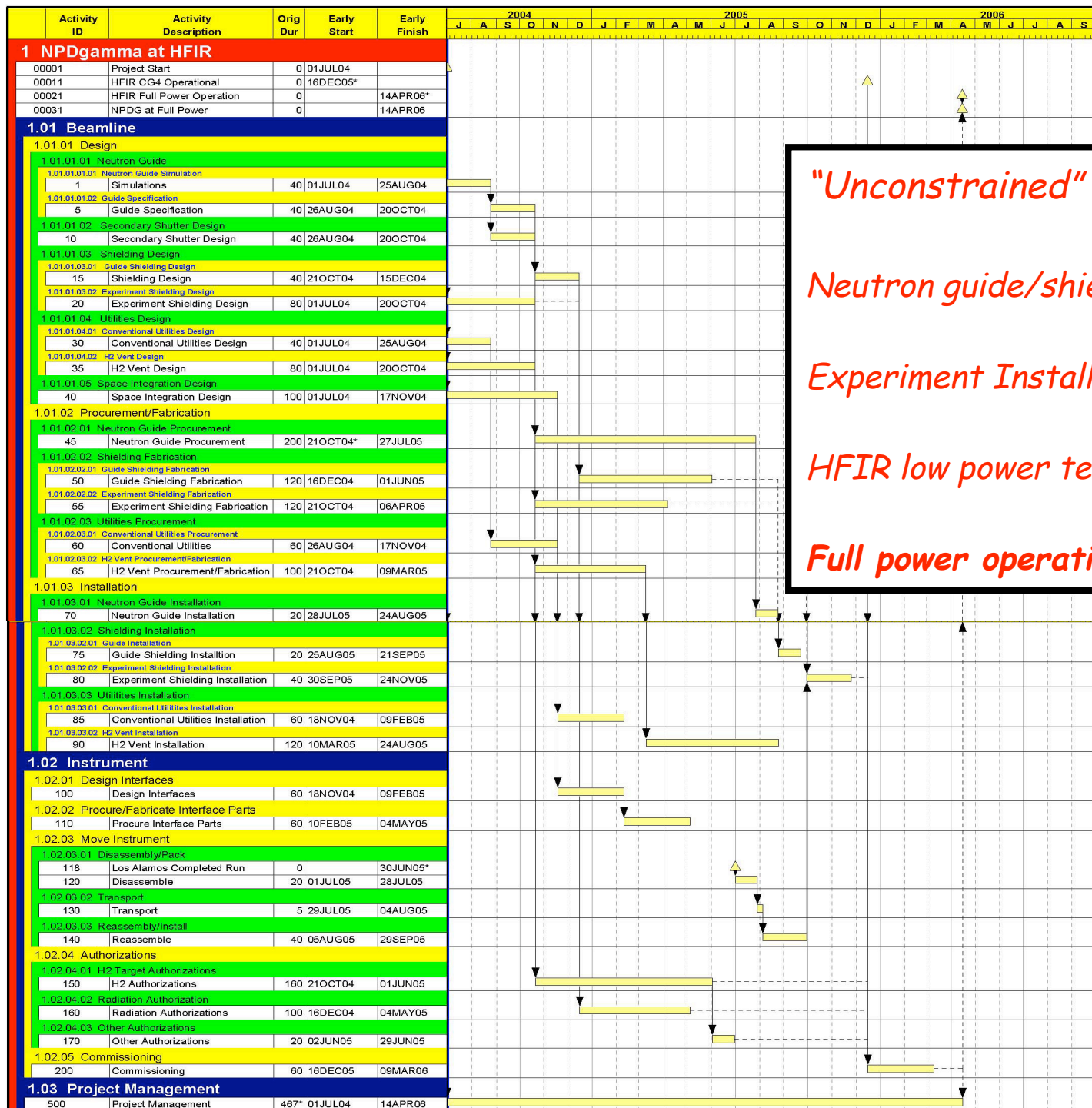
- *Radiation sources*
 - *No fast neutrons or gammas (no direct line of sight to the moderator)*
 - *Main source: 2.2 MeV γ 's from neutron capture in the target*
 - *Cold neutrons are easier to shield against*
- *Requirement*
 - *< 5 mrem/hr for non-restricted access*
 - *5-100 mrem/hr for “radiation area”*
 - *Acceptable condition for infrequent access to the SANS apparatus*

Simple model calculation



Shielding options

- *30 cm concrete*
 - *More work space on the “beam right” side*
 - *Probably a little more challenging to make it structurally sound AND removable*
- *10 cm iron walls*
 - *Needs to surround the experiment symmetrically*
 - *Less work space on the “beam right” side*
 - *Also serves as magnetic shielding*
 - *High field magnets will be used at HFIR (14 T magnet 10m away)*



"Unconstrained" Schedule ()*

Neutron guide/shielding Complete 09/05

Experiment Installation 12/05

HFIR low power tests 12/05

Full power operation 04/06

(*)Assumptions:

- Npdγ completes LANSCE running by mid 05
- HFIR neutron guide ordered early FY05

Action items

- *Finalize the beamline design and generate the equipment specification*
- *Perform more realistic shielding calculation (MCNP?)*
- *Magnetic field calculation with iron shielding*
 - *Field uniformity*
 - *Magnetic shielding factor*
- *Start process for hydrogen target approval*

End of Presentation